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AUTHOR Linnville, Steven E.; And Others
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ABSTRACT

In an investigation using auditory evoked responses (AERs) to compare strongly left- and strongly right-handed adults in their hemispheric processing of speech materials, it was anticipated that AERs would reflect a bilateralization in the left-handed group of subjects and marked hemispheric differences in the right-handed group. In addition, the study investigated whether AERs discriminated between consonant place of articulation cues along phonetic boundaries or whether such responses distinguished between speech sounds varying in discrete and equal acoustical steps regardless of adult labels for the sounds. Subjects listened to four consonant-vowel syllables varying in place of articulation, two perceived as /dae/ and two as /gae/. Twenty-seven randomly ordered repetitions of each stimulus occurred with varied interstimulus intervals, and AERs were recorded from four scalp areas of each hemisphere while subjects attended to stimuli and pressed one of two computer keys. Results indicated that AERs reliably discriminate subjects on the basis of hand preference and discriminate between consonants from different phonetic categories. However, consonant discrimination was not influenced by hand preference. (MSE)

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Electrophysiological Correlates of Handedness and Speech Perception Contrasts

Steven E. Linnville, W. Frederick Wetzel, David J. Leicht, and Dennis L. Molfese

Southern Illinois University at Carbondale

Abstract

Auditory evoked responses (AERs) were recorded from left and right-handed subjects listening to consonant sounds from different phonetic categories. AERs recorded at parietal scalp regions indicated both groups differentiated categorical differences in the sounds. However, hand preferences did not affect hemisphere responses to speech sounds.

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ELECTROPHYSIOLOGICAL CORRELATES OF HANDEDNESS AND SPEECH PERCEPTION CONTRASTS

Steven E. Linnville, W. Frederick Wetzel, David J. Leicht, and Dennis L. Molfese.

INTRODUCTION:

While handedness is thought to be related to hemispheric specialization in language processing, no work has assessed the relation between handedness and speech perception using electrophysiological procedures. The auditory evoked response (known as AER) has been shown to reliably discriminate between different consonant speech sounds which vary in place of articulation or voicing. This study represents the first systematic attempt to use auditory evoked responses (AERs) to compare strongly left- and strongly right- handed adults in their hemispheric processing of speech materials. Given the behavioral,

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clinical, and electrophysiological reports of bilateralization in left-handers with respect to auditory stimuli, it was expected that AERs would reflect this bilateralization in the left-handed group of subjects. However, marked hemispheric differences were anticipated in the right-handed subjects.

In addition, the present study investigated whether AERs discriminated between consonant place of articulation cues along PHONETIC boundaries or whether such responses distinguished between speech sounds which varied in discrete and equal acoustic steps regardless of adult labels for the sounds. Studies of speech perception (such as reviewed by Liberman, Cooper, Shankweiler & Studdert-Kennedy, 1967) have demonstrated that a language listener's ability to discriminate stop consonant sounds such as /d/ from /g/ along an acoustic continuum is limited by the individual's ability to assign unique labels to the sounds. Discrimination is usually very good between speech sounds which are given different names and discrimination is at chance levels when the stimuli share the same phonetic label but differ along some acoustic continuum from each other. Such performance

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in which discrimination is restricted by the phonetic labels assigned the speech sounds is called categorical perception.

While no specific research using AERs to study the PLACE of articulation continuum exists, previous research in our lab using AERs has succeeded in identifying differences between various consonant sounds. For example, Molfese (Brain and Language, in press) reported that the P300-N475 peak amplitude differences reliably discriminated between the consonants /d/ and /g/.

PROCEDURE:

Two adult groups identified as strongly left- or right-handed by the Edinburgh Handedness Inventory (Oldfield, 1971) were tested. Figure 1 depicts that nine subjects were in the left-handed group and nine in the right-handed group.

(Insert Figure 1 about here)

Subjects listened to four consonant-vowel syllables

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which varied in place of articulation, two of which were percieved as /dae/ and two as /gae/. Each stimulus consisted of three formants and had a duration of 300 ms.

The stimuli from Pisoni (1971) varied in equal acoustic steps along a continuum from /dae/ to /gae/. The /dae/ stimuli were identified as P1 and P2 and the /gae/ stimuli as P3 and P4 along this continuum based on their frequency values for the second and third formant. Twenty-seven randomly ordered repetitions of each stimulus occurred with varied interstimulus intervals. Auditory evoked responses were recorded from central, temporal, posterior-temporal, and parietal scalp areas of each hemisphere while subjects attended to each auditory stimulus presentation and pressed one of two keys on an Apple II Plus computer keyboard. The key chosen being dependent upon which stimulus type was percieved. The two keys assigned to represent /dae/ and /gae/ were counterbalanced across subjects.

RESULTS:

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Using a PDP 11/34 computer, each subject's AERs were digitized on-line and averaged for each electrode site and stimulus condition at 5-ms intervals for 100 points. An averaged AER was based on the 27 repetitions per stimulus condition and submitted to three seperate and independent analytic procedures to assess the reliability of the results. The first consisted of the Principal Component Analysis (PCA) which utilized as the input the digitized time points from the average AERs. The results of the PCA were then put into an ANOVA for subsequent analysis. The other two analyses, that is, the Jackknife discriminant functional analysis and the Monte Carlo-like analysis were used to cross-validate the PCA-ANOVA analyses.

.The avereage AERs were input to the PCA using covariance matrix and varimax rotation to isolate 7 factors accounting for 84.08% of total variance. Figure 2 shows the centroid which reflects the electrocortical activity common to all AERs since it is the over-all averaged AER for all subjects across all conditions and electrode sites. Each of the seven factors consists of 100 factor loadings which

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correspond to the 100 original time points sampled over the 500-ms period. The seven factors represents the variability accounted for along the AER waveform. Each of the factors reflect variation to specific portions of the waveform determined by the latencies of the components or peaks in each factor and by the weights of these factors. The weighted scores determine the degree to which a factor influences a specific portion of the AER waveform. The factor peaks can be compared to the major peaks of the centroid to identify the region of the AER that is influenced by each factor. The present paper focuses on Factor 1 and Factor 2 since the variability they accounted for subsequently produced the major stimulus and handedness effects in the ANOVAs.

(Insert Figure 2 about here)

Factor 1 (which accounted for 24.69% of total variance) contains a single peak occurring at 355 ms. This component reflects changes in amplitude which occurred in the AERs in the region of the P315 peak. Factor 2 (12.72% of total variance) defined a wave

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with a peak latency of 475 ms which reflects changes in the region of the AER around the N440 component.

The factor scores for each factor were subsequently put into seven independent Analyses of Variance as the dependent measure in the design of Group (2) by Subjects (9) by Place (4) by Electrode Sites (4) by Hemispheres (2) with repeated measures for Place, Electrode Sites, and Hemispheres. Only effects at $p<.01$ are reported here. Factor 1 was characterized by a Group x Hemisphere interaction, $F(1,16)= 12.60$, $p<.0027$. Scheffe comparisons identified only the right-handers as demonstrating significant hemisphere differences ($F(1,16)= 30.90$, $p<.0001$).

Figure 3 shows the similarity in the waveform for the left-handed group but not in the right-handed group. The third positive peak (P315) overall is more prominent for the right-handed group. An inspection of the left and right hemisphere AERs for the Right Hand group reveals that this P315 peak is more prominent for the left hemisphere than the right hemisphere. No such difference between hemispheres can be noted in the P315 region for the Left Hand group. As noted in the earlier figure (i.e., Figure 2), this factor

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reflected changes in the AER waveform which occurred between 250 and 450 ms.

(Insert figure 3 about here)

Factor 2 was characterized by a Place x Site interaction, $F(9,144)= 2.82$, $p<.0044$. Mentioned earlier, Factor 2 reflected changes in AERs in the region of the centroid's N440 component. A Scheffe planned comparison revealed that AERs discriminated across the categorical phonetic boundaries (/dae/ vs /gae/) at the parietal electrode sites, $F(1,144)= 17.53$, $p<.0002$. However, no differences in the AERs were found between the two /dae/ or between the two /gae/ stimuli.

Figure 4 presents the AERs collapsed within each category distinction so that you see for illustration purposes the average AERs at the /dae/ and at the /gae/ distinctions. Note that the peak-to-peak amplitude in the region of the P315-N440 components for the parietal sites (P3,P4) is larger for the /gae/ stimuli than for the /dae/ stimuli. This difference in amplitude at the parietal sites accounts for the Place

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x Site effects. Notice that there is very little difference in the peak-to-peak amplitudes across the categorical distinctions at the other regions where brain activity was recorded.

(Insert Figure 4 about here)

CONCLUSIONS:

The conclusions of this study is that AERs reliably discriminate subjects on the basis of hand preference. They also discriminate between consonants from different phonetic categories. However, consonant discrimination was not influenced by hand preferences.

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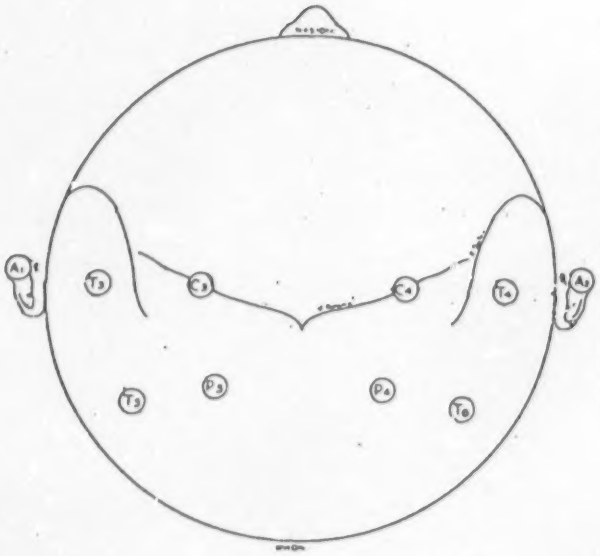
Subjects: 9 Left-Handers (L.Q.= -59.44), 9 Right-Handers (L.Q.= 64.29)
Mean age = 23.83 years

Stimuli: 4 Consonant-vowel syllables (Pisoni, 1971)

Dæ - Gæ

Electrode Sites:



Linked Ears Reference (Jasper, 1958)

Analyses: Auditory Evoked Responses (AERs)

PCA - ANOVA

Stepwise Discriminant Functional Analysis (Jackknife procedure)

Monte Carlo Analysis

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Figure 1.

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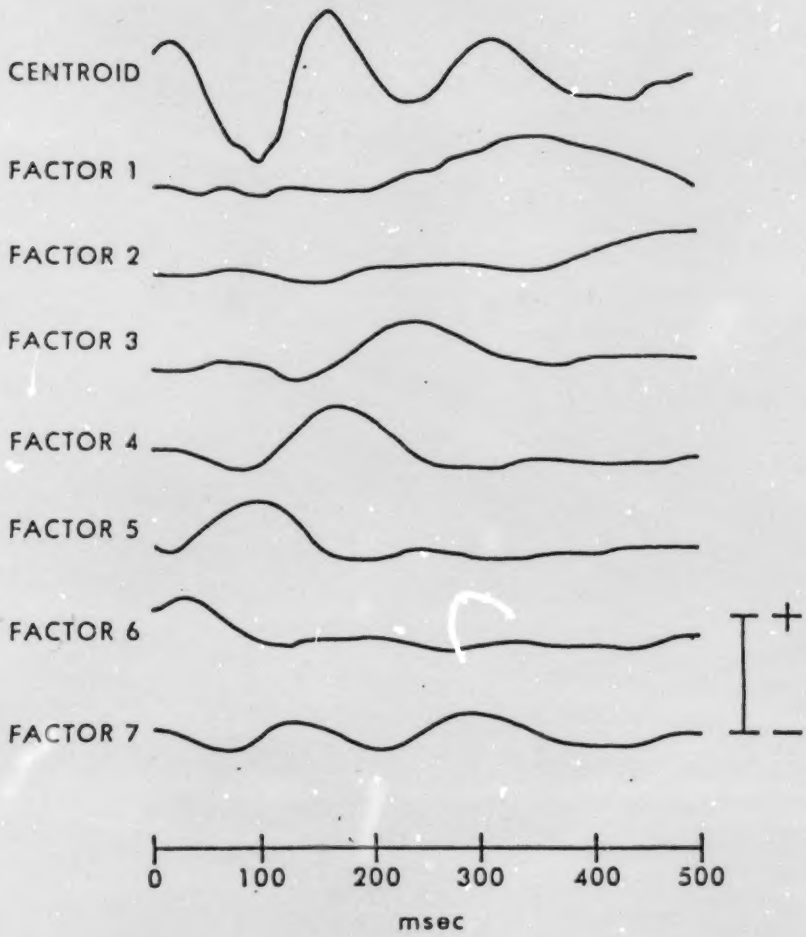

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Figure 2.

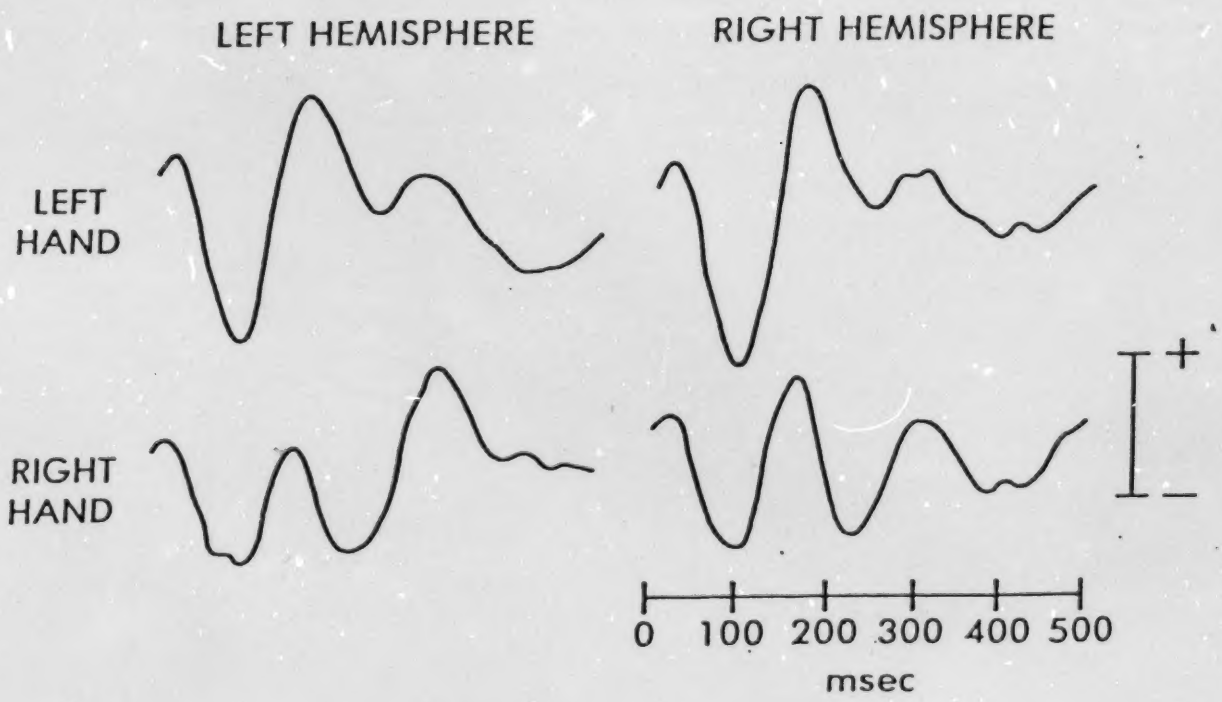

Figure 3.

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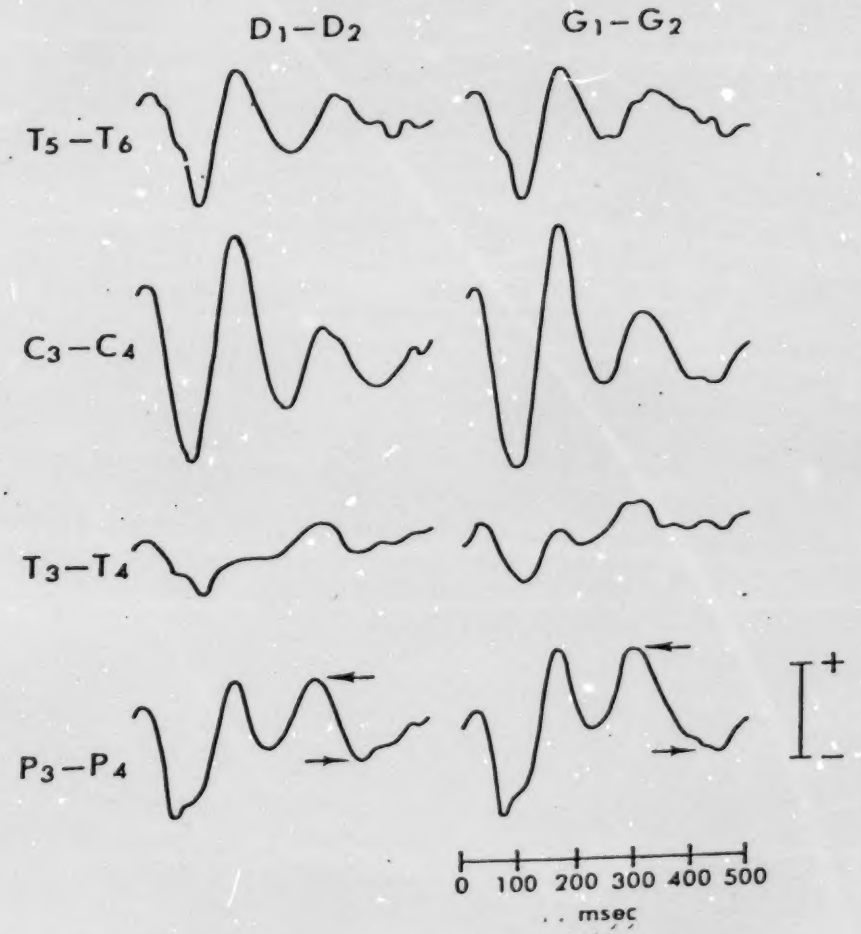

Figure 4.

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